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PASSIVE SMOKING IN THE WORKPLACE: SELECTED ISSUES

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OTA PROJECT STAFF

Passive Smoking in the Workplace: Selected Issues

Hellen Gelband, *Project Director*
Brad Larson, *Research Analyst*
Karl Kronebusch, *Analyst*

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EXECUTIVE SUMMARY

Over the last decade, knowledge about smoking-related disease and death has gained widespread acceptance. As doubt about the effects of smoking on smokers has been replaced by solid evidence, concern over the possible effects of tobacco smoke on nonsmokers has grown. Public pressure has led to a number of actions to restrict smoking for the benefit of nonsmokers, a trend that is continuing. Much of the recent activity has focused on controlling smoking in the workplace. This Staff Paper responds to a request for information about the health effects of passive smoking, the types of policies that are in force in the public and private sectors to control workplace smoking, and the costs and effects of those policies. The request for this study came from Senator Ted Stevens, Chairman of the Subcommittee on Civil Service, Post Office, and General Services of the Senate Government Affairs Committee.

Three major areas are covered in this Staff Paper: 1) a review of the studies of health effects related to passive smoking; 2) a review of current Federal, State and local, and private sector workplace smoking policies; and 3) a discussion of factors to consider in an analysis of the costs and benefits of implementing a workplace smoking policy.

Health Effects and Exposure Measures

There is ample evidence that nonsmokers are exposed to the elements of tobacco smoke when they are around people who are smoking. "Sidestream" smoke (which comes from the lit end of a cigarette, cigar, or pipe), smoke that escapes from the nonburning end, and mainstream smoke that has been inhaled by smokers and then exhaled, all mix with air in enclosed spaces to form "environmental tobacco smoke." "Passive smoking," "involuntary smoking," and

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"exposure to environmental tobacco smoke" are used synonymously in the literature to describe this phenomenon. Environmental tobacco smoke is basically the same, though lower in concentration, as the mixture to which smokers are exposed. Most lung cancer and chronic obstructive lung disease, as well as a large share of heart disease deaths are clearly associated with active smoking, and tobacco smoke contains a number of substances that cause cancer in animals. These facts have led to continuing research to characterize the effects of environmental tobacco smoke on nonsmokers and on some particular groups that might be especially sensitive.

Children and people with preexisting lung disease might be more susceptible than healthy adults to some of the effects of passive smoking. There is substantial evidence linking parents' smoking habits with acute respiratory illnesses, chronic respiratory symptoms, and mild impairments of lung function in children. OTA did not review that literature in detail. The few studies of exacerbation of respiratory symptoms in asthmatics suggest that this population may also be harmed by environmental tobacco smoke.

The most widespread acute effects of exposure to environmental tobacco smoke are eye irritation and irritation of the mucous membranes. Headaches and coughs are also commonly reported. These conditions are not life threatening or fatal, but large numbers of people, including smokers, experience them, some severely. There is little formal research on these acute effects, but they are often tangentially noted in reports of experimental research in this area, and are generally accepted as the result of environmental tobacco smoke exposure. They are, therefore, appropriate to consider in developing smoking policies for the workplace.

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The case is less clear for the contribution of passive smoking to chronic diseases. Debate about the link between passive smoking and lung cancer is one of the most contentious in public health today, and a similar contention has arisen about a possible link with heart disease. The other major category of concern is chronic obstructive lung disease. Because of documented exposure of nonsmokers to the constituents of tobacco smoke and the strong links of active smoking with these chronic diseases, the case for links with passive smoking comes over a foundation of biological plausibility. Epidemiologic studies have been aimed at characterizing the extent to which these diseases are associated with passive smoking in the population.

There is currently a small literature on the effects of passive smoking on the risk of developing chronic obstructive lung disease or heart disease. Some evidence suggests that long-term passive smoking by adults may result in decreased lung capacity. Experimental studies measuring short-term changes in lung function in response to environmental tobacco smoke lend support to this finding. Evidence linking passive smoking to heart disease and cardiovascular symptoms is rather scanty, but studies suggest an acute exacerbation of anginal pain and an increased risk of death from cardiovascular disease. Further research should clarify the role of passive smoking in causing and exacerbating these diseases.

More than a dozen studies have been published during the 1980's that address the possible association of passive smoking and lung cancer. Taken one by one, the studies cannot be considered "definitive;" however most investigators have found that passive smoking elevates a nonsmoker's risk of lung cancer, and results in about half the studies were statistically significant. The consistency of the results argues for stronger conclusions ~~that~~ than could be drawn from individual studies: examined together, the evidence

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is generally consistent with an increased risk of lung cancer, on the order of a doubling of risk, among nonsmokers regularly exposed to environmental cigarette smoke compared with nonsmokers without exposure. These studies do not have the methodological strength of studies of direct smoking and lung cancer, and they cannot be interpreted without considering the effects on their results of potential biases. Despite the remaining uncertainties, the data are sufficient to warrant serious concern. Given the large number of people exposed, even a small increase in the risk of lung cancer from passive smoking would be important.

In summary, the evidence for an association of passive smoking with lung cancer has accumulated during the 1980's, and is consistent with the biologically plausible hypothesis that passive exposure to tobacco smoke can cause cancer. There is evidence that environmental tobacco smoke is an acute respiratory irritant in healthy adults. Relatively strong evidence also supports an association of parental smoking and respiratory infections and symptoms in their children; few studies of this type have been carried out for adults, but the evidence that exists points to a similar relationship. People with preexisting heart or lung disease can be especially sensitive to the effects of passive smoking.

Workplace Smoking Policies

Three Federal agencies administer 90 percent of Federal office space: the General Services Administration (GSA), the Department of Defense (DoD), and the Postal Service. In addition, the Veterans Administration (VA) develops policies for VA hospitals and clinics across the country. Over 2 million civilian Federal workers and 2 million military personnel are affected by the policies of these agencies. Some agency-wide workplace smoking

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policies date back to 1973 or earlier, but most have been enacted or revised more recently. In general, revisions have made policies more restrictive of workplace smoking and have explicitly considered the protection of nonsmokers. Each of the current policies handles smoking in work areas differently, ranging from requesting smokers to consider the comfort of nonsmokers to limiting smoking to designated areas.

Twelve States and more than 70 communities have passed laws regulating smoking in the workplace, most of them in the past four years. Some laws apply only to public workplaces and some to both public and private workplaces. Two provisions are common to many of the State laws: restricting smoking to designated areas and requiring signs to define smoking and nonsmoking areas. Employers are given leeway in designating smoking areas. Most States rely on employers' compliance with the law's intent to provide a healthful environment; two State laws stipulate that the nonsmokers' preferences take precedence in determining work area smoking policies.

Smoking policies in the private sector have shifted in emphasis during the past five years. Previous concern centered mainly on protection of workers and property against cigarette-caused fires, on product purity, and on the protection of equipment. Today, protection of nonsmokers and regulations requiring smoking policies are the forces behind most current policies in the private sector. According to recent surveys, approximately 30 percent of all workplaces have formal smoking policies, and there appears to be a trend toward increasing adoption of policies in the private sector. The most prevalent type of policy is one that restricts smoking in certain areas such as auditoriums, elevators, and conference rooms. Some businesses allow smoking only in specially designated areas. A few companies have recently banned smoking entirely from the workplace, and a small number hire only nonsmokers.

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Costs and Effects of Workplace Smoking Policies

Any administrative or physical changes made to alter smoking behavior in the workplace are likely to generate costs and benefits, including possible cost savings and health benefits. Quantitative information from which to predict the magnitude of total costs and effects is scanty, and therefore OTA has not conducted a formal cost-effectiveness or cost-benefit analysis of workplace smoking policies. Instead, a short discussion of some of the factors that would be included in an analysis of the costs and effects of these policies is provided.

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INTRODUCTION

This Staff Paper responds to a request from Senator Stevens, Chairman of the Subcommittee on Civil Service, Post Office, and General Services of the Senate Government Affairs Committee. Senator Stevens interest relates to a bill he has introduced to restrict smoking to designated areas in Federal buildings.

Three subject areas are covered in this paper: 1) a review of the literature about the health effects of passive, or involuntary, smoking; 2) a description of workplace smoking policies in the Federal Government, at the State and local levels, and in the private sector; and 3) a discussion of factors to be considered in evaluating the cost-effectiveness of smoking policies in the workplace.

Information about health effects comes in part from previous reviews, including work done by the National Academy of Sciences (NAS) and from various volumes of the Surgeons General reports on The Health Consequences of Smoking. A portion, but not all, of the primary health effects literature has been reviewed by OTA. Most of the more recent studies have been reviewed by OTA staff, but for earlier work, published synopses have been relied on.

While some information exists in the literature about workplace smoking policies, the workplace situation is changing rapidly. OTA staff collected a great deal of the information presented here through personal contact with individuals in the Federal Government, in State and local governments, and in the private sector. The section on costs and benefits builds on earlier OTA work on the costs of tobacco-related disease (OTA, 1985).

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As a point of information, the National Research Council's (NRC) Board on Environmental Studies and Toxicology has a study in progress "to evaluate the problem of obtaining optimal measurements of exposure to tobacco smoke by nonsmokers in epidemiological studies and to evaluate the literature regarding health effects of such exposures." NAS has assembled a committee of experts in the relevant fields to carry out this task. The final report will include (National Research Council, 1985):

> a toxicologic profile of sidestream and exhaled smoke; review of its biological, chemical and physical characterization; identification of potential biochemical markers of exposure to a variety of the constitutents of tobacco smoke; review of existing literature on the epidemiology of passive smoking; recommendations for future exposure monitoring, modeling, and epidemiologic research.

EPA's Office of Air and Radiation and the Office on Smoking and Health of the Deparment of Health and Human Services are supporting the NAS study. The report is scheduled for publication in late 1986.

OTA's review comes at a time when public attitudes toward smoking have been changing rapidly. The rights of nonsmokers have gained importance in policy decisions about smoking, which previously were based largely on considerations of efficiency and safety of workers and materials. A July 1985 survey of attitudes toward smoking conducted by the Gallup Organization for the American Lung Association elicited the following responses. Sixty-two percent of smokers, 85 percent of nonsmokers, and 78 percent of former smokers believe that smokers should refrain from smoking in the presence of nonsmokers. There was an increase of several percentage points for each category of respondents since the same question was posed in a 1983 survey. Of particular relevance to this staff paper was the question, "Should companies have a policy on smoking

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at work?" The response of 76 percent of current smokers, and 80 percent of both nonsmokers and former smokers was that certain areas of the workplace should be assigned for smoking. A further eight percent of all respondents thought smoking should be banned totally at work (American Lung Association, 1985c).

This Staff Paper does not provide recommendations or options for public health measures that could be based on the information presented. In accordance with the request for this Paper, the health effects literature is described and evaluated using conventional standards of evidence accepted by the scientific community, and in relation to any specific standards that have been developed for the purposes of regulating environmental or occupational hazards. Those standards, in general, appropriately allow action to be taken with lesser information, and do not necessarily require extensive epidemiologic evidence. For instance, proof of adverse health effects in well designed animal experiments, coupled with evidence that people are exposed to an agent, is sufficient to trigger regulatory action under a number of statutes (e.g., Occupational Safety and Health Act; Federal Food, Drug, and Cosmetic Act; Clean Air Act).

CHARACTERIZING PASSIVE EXPOSURE TO TOBACCO SMOKE

It has been relatively easy to approximate relative exposure levels among smokers to cigarette smoke as the number of cigarettes smoked per day and the number of years that the person has smoked. Quantifying passive exposure of nonsmokers to cigarette smoke is more difficult. One part of the effort to characterize exposure of nonsmokers has been to measure the concentrations of cigarette smoke constituents in indoor environments and to determine the contributions of "sidestream" and "mainstream" smoke to "environmental" tobacco

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smoke. There have been about two dozen investigations of environmental tobacco smoke constituents, including both controlled studies in special experimental chambers and measurements in the air of smoky restaurants, bars, and nightclubs, and other smoky, enclosed spaces. A second and more recent thrust has been to test the body fluids--blood, urine, and saliva--of passively exposed nonsmokers for elevated levels of tobacco smoke constituents or their metabolites (smoke constituents modified within the body to become different chemical entities).

Mainstream, Sidestream, and Environmental Smoke

Mainstream smoke is the tobacco smoke that is generated during a puff and is drawn through the butt end into the smoker's respiratory system. Sidestream smoke comes directly from the burning end of the cigarette, cigar, or pipe. Environmental tobacco smoke refers to what passive smokers are actually exposed to. Smokers, of course, are exposed to both mainstream and environmental smoke.

A smoker's exposure results primarily from the mainstream smoke drawn into the lungs. Non-smokers are exposed primarily to sidestream smoke (nearly 85 percent of the smoke in a room is sidestream smoke) and to smaller amounts of exhaled mainstream smoke, smoke that comes from the nonburning end of the cigarette but is not inhaled by the smoker, and smoke that diffuses through the paper wrapper of the cigarette.

Researchers have designed laboratory apparatus to measure the amounts of the various substances contained in sidestream and mainstream smoke. The instruments measure the concentrations in the smoke immediately after it leaves the butt end (mainstream smoke) or the burning end (sidestream smoke) of the cigarette. Measured in this fashion, the concentrations of many toxic

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substances in captured sidestream smoke are greater than those found in mainstream smoke, e.g., tar, nicotine, benzo[a]pyrene (for a detailed discussion of this topic, see NRC, 1981). This is because different amounts of tobacco are burned when producing mainstream and sidestream smoke, the tobacco's burning temperature is different during puffing compared to when it is only smoldering, and some substances are absorbed by the tobacco and filter as the mainstream smoke passes through.

Because smoke is diluted by air in a room, the exposures of nonsmokers are much less than the measured concentrations of toxic substances in sidestream or mainstream smoke as they emerge directly from the cigarette. In addition to the effects of dilution, environmental tobacco smoke differs somewhat from mainstream and sidestream smoke as a result of chemical and physical changes that occur as mainstream and sidestream smoke cool and react in the air. A number of researchers, including, notably, Repace and Lowrey and their colleagues, over the years, have documented the significant contribution of environmental tobacco smoke to indoor air pollution in studies in enclosed spaces (summarized in Repace and Lowrey, 1985b).

For example, the largest particles in sidestream smoke tend to settle out of the air and some gases react to form different substances. While the differences between what smokers and nonsmokers are exposed to have been frequently emphasized, they are not so great as to require a conclusion that sidestream smoke is dramatically different from mainstream smoke.

Measurements of Specific Constituents of Environmental Tobacco Smoke

More than 2,000 constitutents of environmental tobacco smoke have been identified; many of these substances cause cancer in experimental animals (NRC,

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1981). The National Research Council Committee on Indoor Pollution concluded that passive smoking constituted the "principal source of exposure to many of these compounds" for many people (NRC, 1981). The most frequently-measured products of cigarette smoke in indoor air are carbon monoxide and particulates; other constituents such as dimethylnitrosamine, benzo[a]pyrene, and nicotine, have been measured less frequently. Polonium 210, a radioactive isotope, is also present in environmental tobacco smoke. This literature is reviewed in the 1981 National Research Council study, Indoor Pollutants (NRC, 1981), and in the 1984 Surgeon General's Report on Chronic Obstructive Lung Disease (USDHHS, 1984).

Measurements of environmental tobacco smoke usually distinguish between the gaseous phase and the particulate phase, which consists not only of particles, but some other compounds that adhere to the particles. Investigations with the aim of characterizing levels of exposure, rather than the makeup of the smoke, have chosen to measure one or more compounds thought to be representative of smoke levels. The appropriate constituents to measure differ for particulates, which tend to settles out more quickly, and the gaseous phase, which remains for relatively long periods. The characteristics of enclosed spaces, such as their size and particularly their ventilation, affect the fate of cigarette smoke and therefore the opportunity for passive exposure to smoke.

Carbon monoxide is an easily measured combustion product of burning tobacco, and the most frequently quantified component of the gaseous phase. Carbon monoxide is generated by sources of combustion other than burning tobacco, such as automobiles and gas cooking. The Occupational Safety and Health Administration has set a workplace permissible exposure limit of 50 parts per million (ppm) averaged over eight hours. In 1972, the National

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Institute for Occupational Safety and Health recommended a 10-hour average limit of 35 ppm, and a ceiling limit of 200 ppm. The Environmental Protection Agency National Primary Ambient-Air Quality Standard one-hour limit for carbon monoxide in outdoor air is 35 ppm, and their eight-hour standard, an average limit, is 9 ppm; both limits may be exceeded only once per year.

Carbon monoxide levels in areas where people have been smoking are consistently higher than in "control" areas, which can be outdoors in some cases or indoor spaces where there has been no smoking. Levels of between 10 ppm and 20 ppm often occur in areas such as nightclubs, taverns, and automobiles. Most measurements reported in restaurants are in the range of 5 to 10 ppm. Control levels range from 1 to 3 ppm.

Acrolein is the gaseous constituent responsible for most of the odor associated with cigarette smoke, and also may cause eye and throat irritation. Levels of acrolein found in enclosed spaces under conditions of heavy smoking have exceeded the levels recommended in industrial conditions (NRC, 1981).

Nicotine is found in both the gaseous phase and the particulate phase, and is technically difficult to measure. A few studies have quantified nicotine concentrations, however, showing significant increases over background levels.

A more common measurement has been of total particulates, which also are elevated in areas where people have been smoking. In one study of 69 homes in six cities, average particulate concentrations were 43 micrograms per cubic meter (ug/m^3) of air in homes with one cigarette smoker; 75 ug/m^3 in homes with two or more smokers; compared with 24 ug/m^3 in homes without smokers and 22 ug/m^3 outdoors (Spengler et al., 1981, cited in NRC, 1981). Measures of total particulates may include a great deal of material not associated with tobacco smoke, however, and are influenced by a wide variety of factors, including the

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number of people in a room. A measure of total particulates, therefore, may not be as useful as some of the more specific indicators of the level of environmental tobacco smoke.

Other gaseous constituents that have been measured and found elevated in smoky conditions are nitrogen oxides, nitrosamines, carbon dioxide, methane, acetylene, ammonia, hydrogen cyanide, methylfuran, acetonitrile, and pyridine. Tar, water, toluene, phenol, methylnaphthalene, pyrene, benzo[a]pyrene, aniline and naphthylamine, constituents of the particulate phase, also are elevated in smoky conditions.

Biologic Markers of Passive Smoke Exposure

Certain constituents of tobacco smoke are measurable, some easily so, in the blood, urine, and saliva of smokers. These indicators have been used, for instance, to verify self-reported smoking status, especially among people who claimed to have stopped smoking. In nonsmokers, these same indicators have been used in a number of studies to estimate exposure levels of nonsmokers to varying amounts of environmental tobacco smoke. This is an area of continuing development.

When carbon monoxide is inhaled, it enters the bloodstream via the lungs. Carbon monoxide has an extremely strong affinity for the hemoglobin molecules contained in red blood cells, more than 200 times stronger than the affinity of oxygen molecules for hemoglobin, and competes successfully with oxygen for carriage on the hemoglobin molecule. (At very high doses, carbon monoxide is lethal, as it displaces so much oxygen that the tissues become oxygen-starved.) The combination of carbon monoxide and hemoglobin is a molecule called "carboxyhemoglobin," which can be measured in blood. Studies

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have shown increases in carboxyhemoglobin after exposure to environmental tobacco smoke, which are, as expected, smaller than changes recorded after direct smoking. With a half life of about four hours in blood, carboxyhemoglobin is a good indicator of acute exposure to cigarette smoke (or other types of combustion), but is not a good indicator of chronic exposure (USDHHS, 1984).

Serum thiocyanate (SCN), the metabolite of hydrogen cyanide, a constituent of tobacco smoke, has also been used to verify self-reported smoking status, and has been used in a few studies of nonsmokers' environmental smoke exposure. The value of SCN measurements is limited by many factors unrelated to smoke exposure that influence levels of thiocyanate in the blood.

Nicotine is the most tobacco-specific constituent in smoke that occurs in relatively large quantities. It is possible to measure nicotine in body fluids, but its half life of about 30 minutes makes nicotine unsuitable for estimating chronic exposure. Nicotine has been measured in the blood, urine, and saliva of nonsmokers under both experimental (Russell and Feyerabend, 1975, cited in Feyerabend, Higenbottam, and Russell, 1982) and in typical workplace conditions (Feyerabend, Higenbottam, and Russell, 1982). Under workplace conditions, Feyerabend, Higenbottam, and Russell (1982) found that all nonsmokers had detectable levels of nicotine in saliva and urine. Those nonsmokers who reported exposure to cigarette smoke had significantly higher levels than those who reported no exposure. There was some overlap of nicotine levels of exposed nonsmokers and levels in light smokers in the sample (smokers who had smoked three or fewer cigarettes before the sample was taken), but most of the overlap was with smokers who had not yet smoked a cigarette on the day the urine sample was taken.

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Cotinine appears to be the most promising marker of passive smoke exposure (USDHHS, 1984; Jarvis et al., 1985). Cotinine, the major metabolite of nicotine, has a half life of 20 to 30 hours, so consistent, daily exposure to tobacco smoke should result in elevated levels of cotinine, as measured in blood, urine, or saliva (USDHHS, 1983). Cotinine levels have been measured in the blood and urine of smokers since the late 1970's, and correlate well with levels of smoking. A recent study in smokers (Sepkovic and Haley, 1985) indicates good correlation of cotinine levels and nicotine content of cigarettes smoked, and of changes in smoking habits. That study also points out that cotinine levels in blood, urine, and saliva may change at different rates over time and are not equally sensitive to changes in exposure.

Recently, studies of urine cotinine in nonsmokers have been carried out in attempts to measure passive exposure to cigarette smoke (Wald et al., 1984; Matsukura et al., 1984; Jarvis et al., 1985). Matsukura and colleagues (1984) found higher levels of urinary cotinine in Japanese nonsmokers passively exposed to tobacco smoke at home, at work, or in both locations, and the effects were dose related in both settings. They also compared cotinine levels in nonsmokers from rural areas with those from urban areas, and found that, for nonsmokers who did not live with smokers, levels were significantly lower for rural compared with urban dwellers. Nonsmokers with the highest urine cotinine levels were those exposed to the smoke of more than 40 cigarettes per day at home; those individuals had cotinine levels similar to those of smokers of up to three cigarettes per day. Jarvis and colleagues (1985) studied saliva cotinine in British schoolchildren, aged 11 to 16. They found a strong, statistically significant relationship between the smoking status of parents and cotinine levels in children, with the highest levels in children of two smoking parents.

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Summary: Characterizing Passive Exposure

There is no doubt that tobacco smoking indoors contributes chemical and physical components to the air that are qualitatively similar to the smoke taken into smokers' lungs. The levels of these constituents to which nonsmokers are exposed are much lower levels to which smokers are exposed, and the levels vary depending on the amount of smoking around the nonsmoker, the architecture and ventilation of the structure, other aspects of air quality (e.g., humidity), and chemical and physical changes that take place in the air. Nevertheless, the major components of tobacco smoke have been repeatedly detected in enclosed spaces in which there has been smoking, at higher levels than occur in the absence of smoking. Biologic measurements of tobacco smoke constituents and their metabolites in nonsmokers provide direct, convincing evidence that nonsmokers do have measurable internal exposure to environmental tobacco smoke, and that levels of exposure are related to the number of cigarettes and/or smokers to which they are exposed.

HEALTH EFFECTS: INTRODUCTION

It is now accepted by most scientists and endorsed by several Surgeons General of the United States that cigarette and other tobacco smoking is the cause of most lung cancer and a substantial number of cancers at other sites, a large share of cardiovascular disease, and most chronic obstructive lung disease (COLD) in the United States. OTA estimated that, in 1982, about 314,000 deaths in the United States were related to smoking, amounting to about 16% of all deaths in that year. The exact mechanisms by which tobacco smoking induces disease and the specific components of tobacco smoke that are harmful are not all known. It has been shown, however, that many of the individual constituents of tobacco smoke are carcinogenic in animals.

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The mountain of evidence against tobacco smoking that has accumulated since the 1950's indicates that, among smokers, the level of health risk for the major effects increases with increasing dose. The age when a person starts smoking, the number of years of smoking, and the amount smoked per day all play a part in determining a smoker's risk of smoking-related disease or death. No level of smoking is thought to be "safe." This "dose-response" relationship, which is a commonly accepted tenet in assessing the effects of toxic chemicals, is one reason that investigations of possible health effects of passively inhaled smoke have been undertaken. Passive smoking results in much lower doses than smokers get, so nonsmokers' health risks, per person, should be smaller than the risks of smokers. The number of passively exposed individuals is larger than the number of smokers, however, so even at low levels of risk, a large number of people might be harmed through passive smoking. A particular concern of some investigators has been the possibility that some subgroups in the population, for instance children and those with preexisting lung disease or other chronic diseases, might be more sensitive to the effects of cigarette smoke than would be predicted from studies of smokers.

Much research has been directed at trying to characterize the risks from passive smoking, to determine whether they are or are not important public health concerns. Since the late 1970's, the pace of research on the health effects of passive smoking has increased considerably, and the body of literature now available is adequate, at least in some areas, to draw reasonable conclusions about the importance of passive smoking to the health of nonsmokers. This Staff Paper concentrates on published experimental and epidemiologic studies. Such studies are not available to document many of the specific kinds of symptoms that people experience and report to physicians, such as various allergic reactions. Survey results support the fact that most

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smokers and nonsmokers are "annoyed" by tobacco smoke, annoyance undoubtedly taking in physical as well as psychologic effects (Roper Organization, 1978.

The health effects that have been investigated most extensively in relation to passive smoking in adults are lung cancer and alterations in lung function. There is a small literature concerning the relationship of passive smoking to cardiovascular symptoms and to death from ischaemic heart disease.[1] Although there are isolated reports of a variety of conditions not known to be associated with active smoking in the passive smoking literature, these have not been confirmed, and are unlikely to be important. In general, such associations are not biologically plausible.

A relatively large number of investigations of respiratory infections and lung function in babies and children have drawn links associating parental smoking habits with adverse effects. OTA did not review these studies. However, two critical literature reviews of passive smoking health studies (Weiss et al., 1983; Higgins, 1985) considered the literature on both respiratory illness and lung function, and the 1984 Surgeon General's report (USDHHS, 1984) examined studies of lung function.

In the following pages, the literature on lung cancer, COLD, cardiovascular disease, and irritation is reviewed. The material presented relies to some extent on other published reviews, which are identified in the appropriate sections.

[1]Ischemic heart disease (IHD) describes a spectrum of conditions caused by insufficient oxygen supply to the heart muscle; IHD is the leading cause of death in the United States. The most common manifestations of IHD are angina, acute myocardial infarction (heart attack), and sudden death.

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Lung Cancer and Passive Smoking

The first major studies linking passive smoking to lung cancer, one a study of Greek women (Trichopolous et al., 1981), the other a study of Japanese women (Hirayama, 1981), were published in 1981. Since then about a dozen other studies, of various designs and in different parts of the world, have been completed and the Greek and Japanese studies have been updated (Trichopolous, Kalandidi, and Sparros, 1983; Hirayama, 1984). The study populations are made up mainly, though not exclusively, of women. Studies that have a significant focus on passive smoking and lung cancer have been carried out in Hong Kong (Chan & Fung, 1982; Koo, Ho & Saw, 1983; Koo et al., 1984), Germany (Knoth, Bohn, and Schmidt, 1983) and in different parts of the United States (Garfinkel, 1981; Correa et al., 1983; Kabat & Wynder, 1984; Wu, et al., 1985; Garfinkel, Auerbach, & Joubert, 1985). Table 1 lists these studies and their salient features, as well as several other studies that have some information about passive smoking and lung cancer, but which do not include sufficient data to be considered in an evaluation of this specific question. Epidemiologic study of lung cancer and passive smoking continues, with at least two other studies nearing publication and a heightening of interest among researchers.

In the United States, an estimated 9,000 to 11,000 nonsmokers die of lung cancer each year, out of a total of about 100,000 lung cancer deaths. About one-third of the nonsmokers who die of lung cancer are men and two-thirds are women. The percentages of different cancer types (mainly adenocarcinomas and squamous cell carcinomas) differ between smokers and nonsmokers, suggesting at least some different causes in nonsmokers. Passive smoking may account for a portion of these deaths among nonsmokers, but there also are other as yet unknown, causes.

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Table 1: Epidemiologic Studies of Passive Smoking and Lung Cancer in Nons.. .ers[1]

Reference	Type of Study: Study Population	Study Subjects	Exposure	Risk Estimate (with p values and 95% confidence limits when available)	Comments
Trichopoulos et al., 1981; Trichopoulos, Kalandidi, and Sparros, 1983 (update)	Case-Control: Greek nonsmoking women	77 lung cancer cases excluding adenocarcinomas and terminal bronchial carcinomas 225 orthopedic patient controls, "similar" demographic and socioeconomic profiles	Husband nonsmoker ex-smoker 1 to 21 cig/day 21+ cig/day	 1.0 1.9 2.4 3.4	 p 0.01 for trend (2-tailed)
Hirayama, 1981; 1984 (update)	Prospective cohort: Japanese nonsmoking wives	200 lung cancer deaths among 91,540 wives 40 or older in 1966, followed through 1981	Husband nonsmoker ex-smoker 1 to 21 cig/day 21+ cig/day	 1.0 1.36 1.45 p=0.0337 1.91 p=0.0012	 p=0.00178 for trend
Garfinkel, 1981	Cohort: U.S. nonsmoking married women in American Cancer Society "million person study"	153 lung cancer deaths among 176,739 women followed 1959/60 to June, 1971, 35 to 89 years	Husband nonsmoker <20 cig/day 20+ cig/day	 1.0 1.27 (c.l.: 0.85-1.89) 1.10 (c.l.: 0.77-1.61)	
Chan and Fung, 1982	Case-control: nonsmoking Hong Kong Chinese women	84 lung cancer cases 139 orthopedic patient controls	Husband nonsmoker smoker	 1.0 0.75 (calculated from data in paper)	
Knoth, Bohn, & Schmidt; 1983	Case-population prevalence: nonsmoking German women	39 lung cancer cases	Prevalence of smoking husbands among cases Smoking prevalence of men aged 59-60 in census of 2 million German citizens	61.5% 22.4%	No proper control group.
Correa et al.; 1983	Case-control: nonsmoking Louisiana ever-married men and women	10 male lung cancer cases (8 in analysis) 25 female lung cancer cases (22 in analysis) 180 male and 133 female control patients with diagnoses other than chronic lung diseases or smoking related cancers.	Wife nonsmoker smoker Husband nonsmoker smoker 1-40 pack-yrs 41+ pack-yrs Spouse (combined) nonsmoker 1-40 pack-yrs 41+ pack-yrs	 1.0 2.0 1.0 2.07 1.18 3.52 p<0.05 1.0 1.48 3.11 p<0.05	Small number of cases; 15% of controls had cardio-vascular diagnosis.

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Kabat & Wynder, 1984	Case-control: U.S. nonsmoking men and women	25 male and 53 female lung cancer cases. Equal number of controls matched on age, sex, race, hospital, interview date; with non-tobacco-related diagnoses.	Exposed at home male cases female cases Exposed at work male cases female cases Spouse smokes male cases female cases	 1.3 0.9 3.3 0.7 1.0 0.8	 p=0.05	Risk estimates calculated from data in report. Authors consider data on passive smoking "preliminary."
Gillis et al., 1984	Prospective cohort: Scottish nonsmoking men and women in "partnerships"	6 lung cancer cases among 827 men 8 lung cancer cases among 1917 women All followed 1972/76 through 1982	Partner (usually spouse) nonsmoker smoker male cases female cases	 1.0 3.3 1.0		Too few cases for reliable analysis. Followup ongoing.
Koo, Ho, & Saw, 1983; Koo, Ho, & Saw, 1984; Koo, et al., 1985 (abstract only)	Case-control: nonsmoking Hong Kong Chinese females	88 lung cancer cases 137 district controls	no exposure exposed at home, at work, or both places ≤35,000 hrs exposure >35,000 hrs exposure	1.0 1.24 1.28 0.96	 $p \leq 0.49$ $p \leq 0.44$	Data from Koo, Ho, & Saw, 1984. Koo, et al., 1985 presents results for same study subjects categorized by husbands' smoking; risk estimates for highest categories of total yrs exposure and number of cigarettes/day were 2 to 3, compared with no exposure at home.
Miller, 1984	Case-control: nonsmoking Pennsylvania women	123 lung cancer deaths 414 controls; deaths from other causes	Spouse nonsmoker smoker smoker married to unemployed case	 1.0 1.4 1.9		Did not control for age differences between cases and controls; association probably invalidated with age adjustment.
Wu et al, 1985	Case-control: California nonsmoking white women.	31 lung cancer cases 31 neighborhood controls controls matched on birth date and other selection criteria	No exposure Either parent smoked Spouse smokes Exposed at work	1.0 0.6 1.2 1.3	 (c.l.: 0.5-3.3) (c.l.: 0.5-3.3)	Analysis based on 29 adenocarcinomas; 2 squamous cell carcinomas too few to analyze.
Sandler, Everson, and Wilcox, 1985; Sandler et al, 1985	Case-control: U.S. nonsmoking women	2 lung cancer cases	Too few cases to evaluate			Too few cases to evaluate. Part of larger study of passive smoking cancers at all sites in male and female smokers and nonsmokers; exposure in childhood and adulthood.

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Garfinkel, Auerbach, and Joubert, 1985	Case-control: nonsmoking New Jersey and Ohio women	134 lung cancer cases 402 colon-rectum cancer controls matched on age and hospital All diagnosed 1971-81	Exposed over last 5 years	1.28	(c.l.: 0.96-1.70)	
			Exposed over last 25 years	1.13	(c.l.: 0.60-2.14)	
			Husband [cohabitant] smoked	1.22	(c.l.: 0.97-1.71)	
			Husband [cohabitant] smoked at home	1.31	(c.l.: 0.94-1.83)	
			Hrs/day exposed over the last:			
			5 years:			
			0	1.0		
			1-2	1.59	(c.l.: 0.9-2.72)	
			3-6	1.39	(c.l.: 0.96-2.03)	
			≥7	0.94	(c.l.: 0.69-1.28)	
			All>0	1.28	(c.l.: 0.98-1.66)	
			25 years:			
			0	1.0		
			1-2	0.77	(c.l.: 0.60-0.99)	
			3-6	1.34	(c.l.: 0.96-1.87)	
			≥7	1.14	(c.l.: 0.83-1.57)	
			all>0	1.12	(c.l.: 0.81-1.42)	
			Husband [cohabitant]			
			Nonsmoker	1.0		
			<20 cig/day	0.84	(c.l.: 0.61-1.16)	p<0.025 for trend
			20-39 cig/day	1.08	(c.l.: 0.81-1.44)	
			≥40 cig/day	1.99	(c.l.: 1.13-3.50)	
			cigar/pipe	1.13	(c.l.: 0.78-1.62)	
			all smoking	1.23	(c.l.: 0.94-1.60)	
			Husband [cohabitant] smoking at home			
			none	1.0		
			<10 cig/day	1.15	(c.l.: 0.84-1.58)	p<0.025 for trend
			10-19 cig/day	1.08	(c.l.: 0.76-1.54)	
			≥20 cig/day	2.11	(c.l.: 1.13-3.95)	
			pipe/cigar	1.17	(c.l.: 0.80-1.70)	
			all smoking	1.31	(c.l.: 0.99-1.73)	
			Logistic regression, continuous dose-response model			
			5 yr exposure--10 hr/day	0.93		
			25 yr exposure--10 hr/day	0.85		
			Husband smoked 20 cig/day at home	1.70	p=0.032	
			Husband smoked 20 cig/day outside home	1.26		

[1]For several of the studies listed, this topic is not the only one investigated. For those studies, only the data relevant to this question are included.

Source: Office of Technology Assessment.

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Most of the studies listed above have reported results consistent with approximately a doubling in the risk of lung cancer among nonsmokers heavily exposed to environmental tobacco smoke compared with nonsmokers who were not regularly exposed; some report larger increased risks, some smaller, and two studies found no increase. Passive smoking exposure may vary considerably around the world because of social customs and living conditions, so it is not unreasonable to expect risks to differ among studies. In five studies, statistically significant increased risks are reported.

The International Agency for Research on Cancer (IARC), a unit of the World Health Organization, has recently reviewed the published studies (the study by Garfinkel, Auerbach, and Joubert, described below, had not yet been published when the IARC review took place) as part of a monograph about the carcinogenic effects of smoking, currently in press (IARC, 1986). They note that the risk estimates could actually be somewhat higher or lower than were calculated because of the uncertainties in measurements of passive exposure to cigarette smoke, as well as to other exposures that might have contributed to the development of lung cancer. Because the results could have been influenced by these uncertainties, they conclude that each study is compatible with either an increase or an absence of excess risk of lung cancer from passive exposure to tobacco smoke, even though statistically significant results were reported.

A recent case-control study, published in September 1985, is generally consistent with the results of the other studies, and it is described here in some detail for illustrative purposes. In this study by Garfinkel, Auerbach, and Joubert (1985), the passive smoking histories of 134 nonsmoking women with lung cancer were compared with the passive smoking histories of 402 nonsmoking women with colon-rectum cancer (cancers not known to be associated with smoking). Information was collected about several different aspects of passive

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exposure to cigarette smoke: current smoking habits of husbands or other cohabitants; number of cigarettes smoked per day at home by the cohabitant smokers; number of years the husband or cohabitant smoked; average number of hours per day the women had been exposed to smoke of others during the past five and 25 years at home, at work, or elsewhere, and during childhood.

Data were analyzed using a variety of standard statistical methods. In almost all cases, the women with lung cancer were somewhat more likely to have been passively exposed to cigarette smoke than were the controls, the women with colon-rectum cancer. Most of the differences were not statistically significant, meaning that, using generally accepted statistical standards, the results could be plausibly explained by chance alone. Several comparisons, however, did produce statistically significant results. For those results, chance alone is an unlikely explanation of the findings.

The strongest evidence for an effect of passive smoking in this study is from an analysis of risk related to the number of cigarettes smoked by the husband per day in total, and the number smoked at home. The risks for women whose husbands smoked more than 40 cigarettes per day (2 packs) total, or more than 20 cigarettes per day (1 pack) at home were significantly higher than the risks for women whose husbands did not smoke. More importantly, there was a trend of increasing risk that rose significantly with higher categories of husband's daily cigarette consumption.

As expected, the level of increased risk is much lower than the substantial increase in the risk of lung cancer incurred by smokers. Lifetime smokers are on the order of 10 to 15 times more likely to develop lung cancer than are lifetime nonsmokers (see OTA, 1981). Data from the study by Garfinkel and colleagues described here indicate that the risk of lung cancer among women passively exposed to the smoke of 20 cigarettes per day smoked at home by their

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husbands is somewhat greater than two times the risk of nonsmoking women not passively exposed to cigarette smoke.

All the lung cancer studies have some methodologic weaknesses, and these have been pointed out in some cases by the authors themselves, and by others (Balter et al., 1986). A small number of the studies include so few lung cancers or have such major flaws that they are essentially disregarded in OTA's overall appraisal of the literature. The studies that can be evaluated vary greatly in design and the populations studied vary, yet the results are generally consistent with an increased risk of lung cancer from passive smoking, even taking into account these weaknesses. This consistency across studies lends weight to an overall evaluation that no single study can achieve.

One specific criticism of some of the studies (mainly applying to the case-control studies) is that misclassification of a smoker as a nonsmoker would cause the risk of disease to appear higher than it is. The prospective studies (Hirayama, 1984; Garfinkel, 1981) do not generally suffer from this problem, and the case-control study of Garfinkel and colleagues (1985) described above, went to great lengths to verify smoking history and status for this reason. There is also potential for misclassifying people as to their exposure to environmental tobacco smoke. There is evidence, for example, that assigning passive smoking status to Americans based on the smoking habits of their spouses can result in considerable misclassification (Friedman, Petitti, and Bawol, 1983). Not all smokers smoke very much around their spouses, and people with nonsmoking spouses may be heavily exposed in other environments, particularly the workplace. This type of bias generally tends to make the risk appear less than it actually is. The identification of potential biases and methodologic problems is important for improving future research. Recent studies, such as the one by Garfinkel and colleagues, appear to have benefited from criticism of early studies.

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Repace and Lowrey (1985a) have recently generated two widely-quoted quantitative estimates of the number of lung cancer deaths likely to be attributable to passive smoking per year in nonsmokers in the United States. These investigators did not conduct a specific study; the two estimates are derived using two independent methods, and different sources of data. Repace and Lowrey's estimates were derived by combining data from several epidemiologic studies, surveys, and estimates of nonsmokers' exposure to tobacco tar from passive smoking. One method produced an estimate of 500 nonsmoker lung cancer deaths per year attributable to passive smoking, the other, 5,000 such deaths per year.

Some of Repace and Lowrey's assumptions are inappropriate. In particular, in the method yielding the higher number, they assumed that the entire difference between the lung cancer death rate in a group of nonsmoking Seventh Day Adventists and in a group of nonsmoking (non-Seventh Day Adventist) Southern Californians was attributable to passive smoking. Mortality rates for cancers at other sites are also lower in that Seventh Day Adventist population, and the exact reasons for the differences are not all known. Seventh Day Adventists clearly have a low overall lung cancer death rate because there are few smokers in the population. Repace and Lowrey assume a lower rate of passive smoking than in the general population as well, which is probably justified. However, they use no specific information about the rate of passive smoking in either population they compared. At best, one can conclude that some part of the difference between the two populations may be due to differences in passive smoking rates, but the assumption that it is reasonable to attribute the entire difference to passive smoking is unjustified. The effect of these and other flaws on the final estimates calls into question the reliability of either of these numbers.

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Effects of Passive Smoking on Lung Function

The 1984 Surgeon General's report (USDHHS, 1984) examined the relationship of direct smoking to chronic obstructive lung disease (COLD), which killed more than 66,000 Americans in 1983. The report states:

> ...the experimental and epidemiologic evidence leaves no room for reasonable doubt on the fundamental issue: cigarette smoking is the major cause of COLD in the United States.

The 1984 Surgeon General's report also reviewed the studies of the relationship between passive smoking and COLD and lung function published to that time. The information in this section is taken largely from the Surgeon General's report and from two other recent critical reviews of the literature concerning health effects of passive smoking, by Weiss and colleagues (1983) and by Higgins (1985).

In general, COLD refers to the narrowing of the airways of the bronchial tree and loss of elasticity in the lungs, with a resultant loss of airflow driving pressure. Increased secretion of mucous and an increase in the size of mucous glands, as well as inflammation, abnormal cell types, ulceration, and a variety of other changes in the cellular makeup and condition of lung and bronchial tissue are also signs of COLD. Emphysema, characterized by specific pathologic changes in lung tissue, is the type of COLD most closely associated with smoking. While most diagnoses of COLD are in middle-aged or older people, a diagnosis is preceded by pathologic changes and measurable declines in lung function, which may occur over a period of decades.

The pertinent questions in regard to passive smoking are 1) whether passive smoking contributes to the development of COLD; and 2) whether passive smoking exacerbates the symptoms of or has long-term adverse effects on people with preexisting COLD.

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The studies in this area take two basic forms: 1) laboratory-based experiments in controlled chambers, in which the endpoints are short-term changes in lung function, and 2) epidemiologic studies of the relationship between passive exposure to cigarette smoke and either measures of lung function or morbidity. Most of the epidemiologic studies focus on children, classified according to parental smoking. Investigators have studied the exposure of 1) healthy people, to find out whether those passively exposed to tobacco smoke are more likely to develop respiratory problems than those not exposed; and 2) those with respiratory conditions, particularly asthma, to see whether exposure exacerbates those conditions.

OTA's review concentrates on studies of adults, the main targets of workplace smoking policies. However, children may be passively exposed to tobacco smoke in Federal offices, for example, in agencies where Federal workers deal directly with the public. In addition, at least a portion of the adult population may be as sensitive as children to the effects of passive smoking. Other reviewers have evaluated the evidence for respiratory system effects of passive smoking in children. Weiss and colleagues report that "several studies suggest important increases in severe respiratory illness in very young (less than 2 years old) children of smoking parents." They also cite evidence of respiratory symptoms in older children exposed to environmental tobacco smoke. Higgins concludes, "The evidence linking passive smoking with acute respiratory illnesses, chronic respiratory symptoms and mild impairments of pulmonary function in children is quite strong."

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Experimental Studies of Healthy Subjects

A few investigations have been conducted on subjects exposed to tobacco smoke in laboratory chambers, in which the environment can be carefully

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monitored. Measurements of lung function and, in some cases, measurements of carboxyhemoglobin levels (a measure of carbon monoxide uptake) are carried out at specific times during the experiment. The pulmonary function tests used in these experiments consist largely of measuring the volume of air that is moved in and out of the lungs under different conditions. Two of the three such studies cited by the Surgeon General reported measurable decreases from initial levels in some measures of lung function after exposure of healthy volunteers to tobacco smoke (Pimm, Silverman, & Shephard, 1978; Shephard, Collins, & Silverman, 1979). In the third study (Dahms, Bolin, & Slavin, 1981), which included both healthy volunteers and asthmatics, no statistically significant change in lung function after exposure to environmental tobacco smoke was found in the healthy subjects.

Epidemiologic Studies of Healthy Adults

Four epidemiologic studies of pulmonary function in healthy adults classified as to their passive smoking history are reported in the 1984 Surgeon General's report. Two of the studies (Schilling et al., 1977; Comstock et al., 1981) found no effect on pulmonary function as a function of spouses' smoking status (the study by Comstock and colleagues included only men exposed to wive's smoking). In both studies, however, the study populations were relatively young and might not have had long-term passive exposure to cigarette smoke.

Two other studies have reported statistically significant, small losses in pulmonary function related to passive smoking. In one (White & Froeb, 1980), tobacco smoke at work was used as the measure of exposure, so it was really a study of current exposure, not necessarily representative of long-term exposure. The second was a study of adults in France (Kauffman, Tessier, &

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Oriol, 1983). In this study, nonsmoking women married to smokers had lower values for one measure of pulmonary function than did similar women married to nonsmokers, but the effect did not become apparent until the women had reached age 40. The findings are not ascribable to differences among the women in social class, educational levels, exposure to air pollution, or family size. According to Weiss and colleagues (1983), the results of this study "lend credence to the possible effect of long-term exposure in adult life."

Studies of Adults With Asthma

Two experimental studies of asthmatic adults, conducted in controlled environmental chambers, are cited in the 1984 Surgeon General's report. In one study (Dahms, Bolin, & Slavin, 1981), 10 patients with asthma and 10 healthy controls were exposed to environmental tobacco smoke. Similar increases in blood carboxyhemoglobin levels were found in both groups. The asthmatics, however, experienced worsening pulmonary function over the course of the one-hour experiment, while no change was detected among the controls. In a similar study of pulmonary function (Shephard, Collins, & Silverman, 1979), no such differences were found in objective measures, but in the asthmatic group subjective symptoms--wheezing and chest tightness--were reported.

A recent study (Wiedemann et al., 1986) of nine asthmatics with normal or nearly normal lung function who were asymptomatic at the time of the test, found no significant change in lung function tests after one hour of tobacco smoke exposure in an experimental chamber. In addition to lung function tests, these investigators performed a test to determine whether tobacco smoke exposure increased the reactivity of the subjects' lungs when exposed to a chemical that causes a reaction in the airways. A high degree of reactivity is characteristic of asthmatics, which explains much of their sensitivity to many

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external agents. After exposure to environmental tobacco smoke, the asthmatics in the study were slightly less sensitive to the chemical than they had been before exposure, though they were still more sensitive than were a group of nonasthmatics.

Summary: Effects on Lung Function

There is currently a small literature on the effects of passive smoking on lung function in healthy adults, though there are no longitudinal studies, i.e., studies that follow adults over a period of years to look for changes in lung function or disease status. The experimental studies used a variety of tests and selected participants in different ways, some based on a self-assessment of adverse effects of passive smoking. There is significant heterogeneity among the total population with some form of COLD, and the experimental studies that have been done have looked at small, selected groups which may not represent either the "average" or the most sensitive individuals in that population. It is difficult, therefore, to generalize from these results to the total population with COLD. (For methodologic critiques of these studies, see e.g., Witorsch, 1986.)

The assessment of effects of passive smoking on lung function and disease in healthy and compromised individuals would benefit greatly from further research. However, the studies to date do suggest a small acute effect of passive smoking on lung function in healthy adults and the study by Kauffman, Tessier, and Oriol (1983) suggests a long-term adverse effect. The studies relating passive smoking to acute effects in adult asthmatics are at some variance. Higgins summarizes the evidence by saying, "There is insufficient evidence to permit conclusions about acute effects of passive smoking on patients with asthma or chronic obstructive lung disease but it is likely that some unknown proportion of them will be adversely affected."

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Passive Smoking and Cardiovascular Disease

Smoking is estimated to have contributed to 123,000 deaths from cardiovascular disease in the United States in 1982 (OTA, 1985). This strong relationship underlies much of the concern about the potential for passive smoking to increase the cardiovascular disease risk of nonsmokers.

Epidemiologic Studies

In a study of adults in two populations in Scotland, Gillis and colleagues (1983) found no association of cardiovascular conditions with passive smoking in men or women. Hirayama (1983, cited in Higgins, 1985), in his study of about 91,000 nonsmoking women, found small, statistically significant, increases in the risk of death from ischemic heart disease among wives of smokers and exsmokers. In a study in the United States, Garland and colleagues (1985) found an increased risk of death from ischemic heart disease among wives of current or former smokers, but the result was not statistically significant.

Experimental Studies

The focus of experimental studies has been to determine the effect of acute exposure to carbon monoxide and environmental tobacco smoke on patients with angina. The literature identified by OTA consists of a series of experiments by Aronow and various colleagues, and a study by Anderson and colleagues. This literature is summarized in the 1979 Surgeon General's report, Smoking and Health (USDHHS, 1979). These studies showed that, after

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exposure to environmental tobacco smoke, angina pain began sooner than it did in the absence of exposure. Aronow's work, however, has been questioned (Aviado, 1986) and it is unclear whether the results of his experiments are valid. While there is agreement that an increase of about 5 percent in carboxyhemoglobin levels can measurably shorten the time to onset of anginal pain, there is still insufficient evidence to determine whether an increase in carboxyhemoglobin caused by passive smoking, which has been measured in the range of 2 to 3 percent, can be sufficient to produce an effect. According to Higgins (1985), new studies are under way to investigate the relationship of carbon monoxide exposure to onset of anginal pain.

Summary: Cardiovascular Effects

The available epidemiologic data point to an increased risk of death from ischaemic heart disease among nonsmokers exposed to environmental tobacco smoke, but there are too few studies to make final judgements. The experimental evidence suggests that patients with ischaemic heart disease could suffer a worsening of symptoms with exposure to environmental tobacco smoke.

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Irritation

The most widespread acute physical effects of passive exposure to cigarette smoke are various types of "irritation." Eye irritation is the commonest complaint, but headaches, coughs, and irritation of the nose are also commonly reported. In one study cited in the 1984 Surgeon General's report, 69 percent of subjects reported eye irritation at some time in response to cigarette smoke (Speer, 1968). In one experimental chamber study (Weber, 1984), both a subjective and an objective measure of eye irritation were recorded. After an hour of exposure at smoke levels similar to those found in many public places, including offices, study participants reported increased eye irritation, and the objective measure, the rate of eye blinking, also increased. Eye irritation is also reported incidentally in various experimental studies of passive smoking. In a recent experimental study of adult asthmatics, the authors noted that, "Marked eye irritation was a universal finding," and that nasopharyngeal irritation was also common (Wiedemann et al., 1986). After several minutes in the experimental chamber, most subjects chose to wear goggles offered to protect their eyes from smoke.

There is sufficient evidence from surveys and observational studies that most people, including many smokers, are physically irritated by tobacco smoke. The means to test this belief is limited and few studies have done so, but the effect is generally accepted.

Health Effects: Summary

Taken piece by piece, much of the evidence for adverse health effects related to passive smoking is equivocal. As is the case for nearly every other body of health effects literature, there are few "definitive" studies

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that by themselves change scientific thinking. Conclusions are drawn by examining the aggregate of studies and weighing their designs, flaws, and findings. In the case of passive smoking, the available evidence taken together supports stronger conclusions than do the individual studies.

Studies of respiratory effects suggest that people with asthma can be harmed by environmental tobacco smoke. Healthy adults may experience measurable disturbances of pulmonary function from passive smoke exposure. There is evidence that environmental tobacco smoke is an acute respiratory irritant, and an eye irritant. While the acute, short-term effects of passive smoking are by themselves relevant for a study of workplace smoking policies, their long-term health implications are less clear.

Evidence linking passive smoking to cardiovascular disease and symptoms is still rather scanty, but some studies suggest both acute exacerbation of angina pain and an increased risk of death from heart disease. The plausibility of these conclusions is supported by the known cardiovascular effects of direct smoking.

The epidemiologic evidence from a number of studies is generally consistent with the biologically plausible hypothesis that passive exposure to tobacco smoke can cause lung cancer. Taken together, the evidence points to a carcinogenic effect smaller than that observed for direct cigarette smoking. The published studies to date have not been free of flaws in methodology and design, particularly in their measurement of the extent of subjects' exposure to environmental tobacco smoke, but these flaws do not invalidate the studies. Even the best of such studies have not achieved the methodological precision of studies of direct smoking and lung cancer. Still, because so many people are currently exposed to environmental tobacco smoke, even a small increase in the risk of lung cancer from passive smoking would be important. Despite the

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uncertainties in the evidence, the data are sufficient to warrant serious concern.

SMOKING POLICIES IN THE FEDERAL WORKPLACE

Three agencies are responsible for administering smoking policies in 90 percent of all Federal office space: the General Services Administration (GSA), the Department of Defense (DoD), and the Postal Service. In addition, the Veterans Administration (VA) develops smoking regulations for 172 VA medical centers and 225 clinics.

This staff paper comes at a time of much activity related to Federal smoking policies. In the first four months of 1986, both DoD and the VA medical centers modified their smoking policies, while GSA was in the midst of policy revision. OTA did not attempt to evaluate the effectiveness of these policies, and the extent to which they are implemented varies from office to office. Federal employees work in a variety of settings, but policies that affect Federal office workers are focused on in this staff paper.

General Services Administration Regulations

GSA develops regulations for the buildings it manages in its role as administrator of Federal property. In 1983, GSA administered 34 percent of all Federal office space (U.S. GSA, 1984). GSA's smoking regulations are the largest single source of workplace smoking policies for civilian Federal employees.

History of GSA Regulations

GSA's Public Buildings Service, responsible for the operation and

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maintenance of many Federal office buildings, first issued smoking regulations in 1973 after reports from the Surgeon General on the dangers of smoking and after receiving requests from nonsmokers that smoking in Federal buildings be restricted or prohibited (U.S. GSA, undated). The first regulations prohibited smoking in certain common areas, such as conference rooms, auditoriums, and elevators. They also required nonsmoking areas in GSA cafeterias and limited smoking in certain medical care facilities. They encouraged, but did not require, nonsmoking areas in open office spaces (U.S. GSA, 1973). In 1976, after resistance from Federal agencies, GSA permitted smoking in conference rooms if, in the opinion of the local building manager, the room was "properly ventilated" (U.S. GSA, undated; U.S. GSA, 1976). At the urging of the Department of Health, Education, and Welfare (DHEW) and the Office on Smoking and Health, GSA strengthened its regulations in 1979. Current GSA regulations are described below.

At the time of this paper, GSA is in the late stages of proposing more restrictive regulations, which will be printed for comment in the Federal Register. A final regulation will be issued based on comments received (Dutton, 1986).

Content of GSA Regulations

The intent of GSA's current workplace smoking regulations is to provide a "reasonably smoke-free environment in certain areas" of GSA-administered buildings. The regulations cite a need to control smoking in some areas "because smoke in a confined area may be irritating and annoying to nonsmokers and may create a potential hazard to those suffering from heart and respiratory diseases or allergies" (44 FR 22464). In all buildings administered by GSA, smoking is prohibited in auditoriums, conference rooms,

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classrooms, and elevators unless excepted by the agency head. The regulations also require nonsmoking areas, designated by signs and determined by the building manager, in building cafeterias.

Smoking in open office areas, where smoke may drift into a nonsmoker's work area, is often a point of contention. GSA's regulations are less strict in open office areas than in areas such as conference rooms, although the regulations suggest that creating nonsmoking open office areas should be "thoroughly investigated" provided that "(1) efficiency of work units will not be impaired, (2) additional space will not be required, and (3) costly alterations to the space or procurement of additional office equipment will not be necessary" (41 CFR part 101-20). Workers in an office "may unanimously declare that office as a 'no-smoking' area." However, because the decision must be unanimous, smokers retain the right to reject a no-smoking policy in the work area.

Implementation of GSA Regulations

While agencies with buildings administered by GSA are required to comply with GSA workplace smoking regulations, the agencies, not GSA, are responsible for the implementation and enforcement of the regulations. There exist, therefore, a variety of conditions in Federal workplaces based on the minimum requirements established by GSA. The regulations state that "nothing in these regulations precludes an agency from adopting more stringent rules in space assigned to them," and some agencies, although certainly not a majority, have adopted more stringent policies. The Agency for International Development (AID), for example, chose to limit smoking in the workplace in August of 1985 after a poll showed that 90 percent of its employees favored restrictions (U.S. AID, 1985). AID's current policy stipulates that shared

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work areas will be nonsmoking unless unanimously declared smoking by employees in the area. This policy makes nonsmoking the norm, compared with GSA's regulations in which smoking work areas are the norm. AID officials reported few problems implementing the policy (Alli, 1986; Cahn, 1986).

A complete listing of policy variations under GSA's regulations is beyond the scope of this staff paper, but there are other notable examples of agencies that have adopted stricter policies. The Indian Health Service (IHS), an agency of the U.S. Public Health Service, has announced its intention to ban smoking from its health and administrative facilities. Since late 1983, the Keams Canyon IHS hospital in Arizona has been smoke free. One hundred sixty-five of 180 major IHS facilities have banned smoking, and another ten facilities have pledged to ban smoking by September 1986 (Fairbanks, 1986). However, in Oklahoma, a grievance has been filed by an IHS employee charging that the ban in that facility was declared without consulting the labor union. Should the grievance be upheld, IHS management will have to negotiate with the union in that facility. Region X of the Department of Health and Human Services (HHS) in Seattle banned smoking in September of 1984 after surveying employee attitudes and consulting with its two labor unions (U.S. DHHS, 1985a; McDonald, 1986).

Department of Defense Policies

The Department of Defense (DoD) is the largest employer in the Federal workforce, employing more than 1 million civilian workers (34 percent of the Federal civilian workforce) and over 2 million military personnel on active duty. DoD manages 31 percent of all Federal office space (U.S. GSA, 1984).

History of DoD Smoking Policies

The Office of the Assistant Secretary of Defense for Force, Management,

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and Personnel developed DoD's first workplace smoking policy in 1977. Recently, the policy has been modified and incorporated into a more general health directive. The original policy prohibited smoking in certain portions of all DoD buildings, including auditoriums, conference rooms, and classrooms. It also required the establishment of nonsmoking areas in eating facilities "wherever practicable." Smoking was permitted in shared work areas "only if ventilation is adequate to remove smoke from a work area and provide an environment that is healthful" (U.S. DoD, 1977). DoD defined "adequate ventilation" as at least "10 cubic feet of fresh air per minute per person."[1] In theory, this meant that if a nonsmoker were to formally complain about smoke in his or her work area, an industrial hygienist would be called in to take measurements, the results of which might lead to a nonsmoking policy for the area. DoD's original workplace smoking policy was superseded by a more general health directive on health promotion signed by the Secretary of Defense on March 11, 1986.

Content of DoD Smoking Policies

The workplace smoking policies established in DoD's recent health directive are somewhat more stringent than the policies implemented in 1977, although the changes do not appear to be large. Smoking is prohibited in auditoriums, conference rooms, and classrooms, just as it was in 1977, and in the new directive, nonsmoking areas are required in all eating facilities rather than just "wherever practicable." The new directive also states that "smoking shall not be permitted in common work areas shared by smokers and

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[1]While this ventilation rate is greater than the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) guidelines for offices without smoking, it is only half of the current guideline for offices with smoking.

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nonsmokers unless adequate space is available for nonsmokers and ventilation is adequate to provide them a healthy environment" (U.S. DoD, 1986a), although "healthy environment" is not defined in the policy. The new directive also places more emphasis on smoking cessation programs than the 1977 policy. After a recent controversy over the sale of cigarettes at reduced prices in military exchanges and commissaries, the Secretary of Defense announced DoD's intention to carry out "an intense anti-smoking campaign" in the military, rather than increase cigarette prices (U.S. DoD, 1986b). Reduced cigarette prices were seen as part of commissary privileges, which allow military personnel to buy goods at reduced prices.

Implementation of DoD Policies

Major divisions within DoD include the Office of the Secretary of Defense, the Military Departments of the Army, Navy (which includes the Marine Corps), and Air Force, and the twelve Defense Agencies (e.g., the Defense Intelligence Agency and the Defense Mapping Agency). The DoD health directive requires each division to implement the health promotion directive, which includes policies on smoking in the workplace. Each of the divisions, therefore, drafts its own set of policies based on the requirements of the directive (Gunnels, 1986). Implementation of the policies may be stronger than the requirements set by the directive. For instance, after consulting with its labor unions, the Madigan Army Medical Center in Tacoma, Washington banned smoking from its facilities.

Postal Service Policies

The U.S. Postal Service, an independent establishment of the Executive branch, employs over 700,000 workers and administers 25 percent of all Federal

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office space (U.S. GSA, 1984). The Postal Service is divided into five regional areas within the United States, and among these areas there are nearly 40,000 branch offices and stations.

History of Postal Service Smoking Policies

Unlike many other Federal agencies, the Postal Service has a long history of workplace smoking policies. In contrast to the policies adopted by GSA in 1973 and DoD in 1977, the Postal Service policies were issued because of the flammable nature of the mail rather than for health concerns. This consideration has been the primary impetus for smoking policies in the Postal Service, and it has been only recently that the health of nonsmoking employees has been considered a factor in determining workplace smoking policies (Hermann, 1986).

Content of Postal Service Regulations

Today the flammable nature of the mail is still the main focus of Postal Service workroom smoking policies. The regulations state that "smoking areas must be clearly designated" and that "employees must not smoke, under any circumstances, while receiving mail from the public, around belt conveyor tunnels, collecting mail from letter boxes, loading or unloading mail, distributing mail into pouches and sacks, or hanging, working, or closing pouches or sacks on racks" (U.S. Postal Service, 1983).

These limitations apply particularly to postal workroom areas; in contrast, office smoking policies are not clearly delineated, varying from office to office (Hermann, 1986). Postal regulations state that "smoking on duty is a privilege, not a right, and must not be indulged in to the detriment of the Postal Service or an employee's work, nor at the risk or discomfort of

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nonsmoking employees" (U.S. Postal Service, 1983). While this reflects consideration to nonsmokers, it does not establish procedures to be followed in carrying out a policy. The Postal Service headquarters in Washington has issued a smoking policy for its immediate office; smoking there is prohibited if a nonsmoker objects (U.S. Postal Service, 1984). However, this policy is presented to other offices as an example only and does not require other offices to establish similar policies.

Implementation of Postal Service Smoking Policies

To a much greater extent than other Federal agencies, Postal Service employment policies are governed by the process of collective bargaining. The Office of Safety and Health within the Postal Service has a contractual obligation to provide notice to unions and, if requested, meet with them while making policies which relate to working conditions (Jones, 1986). If a new policy were to be agreed upon, it would be printed and distributed through the Postal Bulletin to the five regional offices and nearly 40,000 branch offices across the country.

Veterans Administration Policies

Two sets of policies form the basis of most Veterans Administration (VA) workplace smoking restrictions. The Department of Medicine and Surgery (DM&S) employs 190,000 (82 percent) of the VA's employees and administers the VA's hospitals, clinics, and nursing homes. GSA administers most of the remainder of VA buildings. GSA regulations are discussed above; this section focuses on the policies set by DM&S within the VA.

History of Veterans Administration (DM&S) Policies

The first DM&S smoking policy was written in 1978, and since then it

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has been revised four times. The first policy prohibited smoking in certain places, such as patient interview areas, examination areas, and conference rooms. It also stated that, "where space accommodations permit," smoking and nonsmoking sections should be established in areas including waiting areas, dining rooms, patient day rooms, and patient rooms (U.S. VA, 1978). The first three policy revisions included mostly minor changes which gradually broadened the policy (U.S. VA, 1981, 1982, 1984). The most recent revision, approved in March of 1986, includes extensive changes.

Content of Veterans Administration (DM&S) Policies

The new DM&S policy states that "near each medical center entrance there will be a sign stating 'No smoking allowed in this medical center except in designated areas'" (U.S. VA, 1986). Most often, specific dayrooms will be designated as smoking areas (Mather, 1986). The policy also allows smoking and nonsmoking sections in waiting areas and dining rooms, and "adequate ventilation and/or smoke eaters [mechanical devices designed to reduce smoke levels] must be provided in all designated smoking areas." Whereas patients were allowed to smoke in rooms when space allowed and the physician approved under previous policies, under the new policy, patients with physician approval "will be escorted to a designated smoking area when necessary. Those patients whose smoking would, in the judgement of an appropriate health professional, pose a risk to themselves or others, will be allowed to smoke under strict supervision only." The policy also calls for educational programs on the hazards of smoking and smoking cessation clinics.

Implementation of Veterans Administration (DM&S) Policies

The policy, dated March 5, 1986, has not yet been fully implemented.

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VA medical centers are encouraged to designate a "smoking control officer with responsibility for implementing the smoking policy at that facility." In addition, people who smoke within a nonsmoking area may be subject to a fine of up to $50, although voluntary compliance through a notification system is encouraged.

STATE AND LOCAL WORKPLACE SMOKING LAWS

An increasing number of State and local government laws have restricted smoking in the workplace, particularly since 1983. Since that time, seven State laws and more than 70 community ordinances have regulated smoking in either the public or private sectors in addition to five other States which already had such a law. OTA compiled a list of State laws regulating workplace smoking and examined a few sample local ordinances.

State Workplace Smoking Laws

Minnesota was the first State to regulate smoking in the workplace with the passage of its Clean Indoor Air Act of 1975. Utah followed in 1976, Montana and Nebraska in 1979, and since 1981, nine other States have passed laws regulating smoking in the workplace. The Rhode Island Legislature recently passed a bill restricting smoking in the workplace which will be presented to the Governor; in other States, including Colorado, Maryland, and Virginia, such legislation has been proposed and defeated.

OTA contacted State health officials responsible for implementing State workplace smoking laws and compiled a table of States with such laws and components of the laws (see Table 2). The table includes the year the law was enacted, which in some cases was the year before the law was actually implemented.

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Table 2: State Laws Regulating Smoking in the Workplace[a,b]

State	Year Enacted	Written Smoking Policy Required	Smoking only in Designated Areas	Signs Required	Nonsmokers Prevail in Disputes	No Discrimination Against Nonsmokers	Penalties
Alaska[c]	1984		X	smoking no smoking			smokers $10-50 employers $20-300
Connecticut	1983	X					
Florida	1985	X	X	smoking			smokers up to $500
Maine	1985	X	X			X	employers up to $100
Minnesota	1975		X	smoking no smoking			smokers--petty misdemeanor employers--injunction
Montana[d]	1979			smoking and/or no smoking			employers--misdemeanor, $25
Nebraska	1979		X	smoking no smoking			smokers--misdemeanor
New Hampshire[c,e]	1981		X	no smoking			smokers--violation employers--injunction
New Jersey[f]	1985	X		smoking no smoking			
New Mexico[c,f]	1985	X		no smoking	X		smokers $10-25
Utah	1976[g]		X	smoking no smoking	X	X	smokers--infraction, up to $299 employers--misdemeanor
Wisconsin[c]	1984		X	smoking			employers $25

[a]OTA's list drawn from lists by the American Lung Association and Office on Smoking and Health. Some States were excluded from OTA's list because State health officials reported that their smoking law did not apply to workplaces. These States were: Arkansas, California, Hawaii, Iowa, Nevada, North Dakota, Ohio, Oregon, and Washington.

[b]At the time this was compiled, the Rhode Island Legislature had passed a law requiring all employers to develop a policy which included nonsmoking areas. The Governor had not yet acted on the legislation.

[c]State and local workplaces only.

[d]In State offices with 7 or more employees, smoking and nonsmoking areas must be designated.

[e]Smoking and nonsmoking areas must be segregated; if not possible, then smoking must be prohibited.

[f]Nonsmoking areas must be designated.

[g]Amended in 1986, penalties for smokers reduced from misdemeanor.

Source: Office of Technology Assessment

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State laws restrict workplace smoking in different ways; some simply require each workplace to post the policy, many others restrict smoking to designated areas only. Common to many of the laws is an explicit intention to protect the health and comfort of nonsmokers. The twelve States with workplace smoking laws have adopted one or more of the following components.

Components of State Workplace Smoking Laws

Restricting smoking at State and local workplaces. Laws in Alaska, New Hampshire, New Mexico, and Wisconsin restrict smoking at State and local workplaces only; laws in the eight other States that restrict smoking in the workplace apply to both public and private workplaces. The intent of laws in the first four States is to regulate smoking in "public places," which are defined from State to State to include places such as libraries and museums as well as State workplaces. Each of the four laws restricts smoking to designated areas in the workplace. In Alaska, after some confusion over a provision requiring "reasonable accommodations" for the needs of smokers and nonsmokers, a State Labor/Management Committee developed guidelines for establishing smoking and nonsmoking areas in State buildings (Ballentine, 1986).

Requiring a written policy. Laws passed in Connecticut, Florida, Maine, New Jersey, and New Mexico (State and local workplaces only) all require that employers establish a written smoking policy. Connecticut requires only that "each employer shall establish and post written rules governing smoking and nonsmoking in that portion of any business facility for which he is responsible." The law, which applies only to businesses with 50 or more employees in a "structurally enclosed location," does not specify the policy's content; an employer may choose to allow smoking throughout the

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workplace. New Jersey's law, passed in late 1985, also specifies that businesses with 50 or more employees must establish a written policy; however, New Jersey's law also requires that employers designate nonsmoking areas. The laws in Florida and Maine are the most explicit of the five States which require employers to develop policies. In Florida, the policy "shall take into consideration the proportion of smokers and nonsmokers" and prohibit smoking except in designated areas. In Maine also, the policy "shall prohibit smoking except in designated smoking areas."

Limiting smoking to designated areas. Restricting smoking to designated areas is a common provision to most State laws regulating smoking in the workplace. Eight of the twelve States with workplace smoking laws have such a provision (see Table 2). Minnesota's law was the first among States to limit smoking in the workplace, stating that "no person shall smoke in a public place or at a public meeting except in designated smoking areas." Several States, including Utah, Nebraska, and Florida followed Minnesota's example, using language from Minnesota's law to restrict smoking to designated areas. Each of these States defines "public place" to include places of work; this definition is important because other States, such as Oregon, also restrict smoking in public places, however Oregon does not include the workplace in its definition of a "public place."

One issue raised by the language of the State laws is the definition of "designated area" for smoking. In each of the eight States, designation of smoking areas is left up to the person in charge of the public place within the boundaries established by the intent of the laws. Although laws in New Mexico (State and local workplaces only) and Utah are the only ones to specifically state that nonsmokers' preferences prevail over smokers' preferences, each of the above laws was written with the intention of

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providing a healthful work environment. Shared work areas may thereby be discouraged from being designated smoking; however, in some cases an employer may technically be in compliance with the law but in conflict with its intent by designating a shared work space as a smoking area. (Richards, 1986). In Maine, the State health department considers the intent of the law as well as its technical specifications if legal action against an employer is required (Maloney, 1986).

Other guidelines and constraints influence the designation of smoking areas. Negotiations with labor through collective bargaining may be required. Also, all laws except those in Alaska and Maine state that "existing physical barriers and ventilation systems" should be used to separate smoking and nonsmoking areas, eliminating a mandate for costly alterations. Laws in Minnesota, Utah, and Nebraska, explicitly mention that offices occupied solely by a smoker or group of smokers may be designated as smoking areas; all the other State laws implicitly allow this.

Requiring signs to be posted. Ten States require that signs designating smoking and/or nonsmoking areas must be posted in the workplace. Alaska (State and local workplaces only), Minnesota, Nebraska, New Jersey, and Utah all require signs designating smoking and nonsmoking areas. Florida and Wisconsin (State and local workplaces only) require that signs be posted in smoking areas, while laws in New Hampshire and New Mexico require signs only in nonsmoking areas in State and local workplaces. Montana's law, one of the least restrictive State laws regulating workplace smoking, requires only that a smoking or no-smoking sign be posted, depending on the policy set by the employer. Many of the laws specify a minimum size for the signs; in Minnesota, signs "shall be in printed letters of not less than 1.5 inches (3.8 centimeters) in height," unless used on a table or seat.

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Giving preference to nonsmokers in resolving conflicts. In State and local offices in New Mexico occupied by smokers and nonsmokers, the employer must provide a smoke-free work area to accommodate any employee who requests one as long as costly modifications are not required. And Utah's law, which limits smoking to designated areas, requires employers to comply by:

> "allowing an employee who has a defined, individual work area in the workplace to designate his immediate work area as a "no smoking" area and to post it with appropriate signs. With regard to this subsection, the employer shall give precedence to the rights of a nonsmoking employee when attempting to reach agreements between the preferences of smoking and nonsmoking employees."

Although Minnesota's law does not have a clause explicitly giving preference to nonsmokers, State health officials interpret the law's intent and its sections on designation of smoking areas as giving precedence to nonsmokers' concerns (Thompson, 1986).

Prohibiting action against nonsmokers who complain about smoking. Two State laws explicitly prohibit taking action against nonsmokers because they complain about smoking. In Utah, an employer is not allowed to "discriminate against an employee who expresses concern about smoke pollution in the place of employment which is detrimental to his health or comfort." And in Maine, "it is unlawful for any employer to discharge, discipline or otherwise discriminate against any of its employees because that employee has assisted in the supervision or enforcement of this section."

Enforcement of State Laws

States have various provisions for enforcement of laws regulating workplace smoking, but in general, the laws tend to be self-enforcing (Shopland, 1985; Kahn, 1983). In nearly all States, the State health department or its local subdivision is responsible for enforcement of the law. Some States, such as Connecticut and New Jersey, essentially have no

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provisions for enforcement or penalties, while others, Utah and Florida in particular, may assess fines up to $299 and $500 for violation of the law, although in practice such high fines have never been assessed. In seven of the twelve States a smoker can be cited for a non-criminal violation or charged for a misdemeanor if found smoking in a nonsmoking area. Also in seven of the States an employer who fails to implement provisions of the law may also be held responsible, either through fines, a court injunction, or misdemeanor conviction.

In telephone conversations with State employees responsible for implementing the laws, OTA found that most of their effort was spent during the phase-in period when employers were uncertain about compliance standards. States which have had workplace smoking policies for a few years reported few enforcement problems. Utah's law has been in effect since 1976, and the State official responsible for enforcement estimated that in recent years about 6 employers had been fined from $25 to $50 (Marx, 1986).

Local Workplace Smoking Ordinances

More than 70 communities in California have passed ordinances regulating smoking in the workplace (Americans for Nonsmokers' Rights, 1986). California has been by far the most active State, but communities in other States, including New York, Ohio, and Colorado have also passed workplace smoking ordinances. Local workplace smoking ordinances are a recent and rapidly-developing phenomenon; nearly all have been written since 1983, and in the first two months of 1986, Nassau county in New York adopted and New York City's Mayor Koch proposed workplace smoking ordinances.

City Ordinances

The most active State in passing workplace smoking ordinances at the

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city level has been California. After nonsmokers' legislation was defeated twice at the State level, groups such as the Californians for Non-smokers Rights shifted their emphasis to ordinances at the local level (Shopland, 1985).

In 1983, 13 California cities passed nonsmoking ordinances, including San Francisco and Palo Alto (American Lung Association, 1985a). In San Francisco, each employer must establish an office smoking policy. San Francisco's workplace smoking ordinance states that "if an employer allows employees to smoke in the workplace, then this ordinance requires (1) that the employer make accommodations for the preferences of both nonsmoking and smoking employees, and (2) if a satisfactory accommodation to all affected nonsmoking employees cannot be reached, that the employer prohibit smoking in the office workplace" (San Francisco Ordinance 298-83, in American Lung Association, 1985a). The ordinance does not apply to enclosed offices occupied solely by smokers, State or Federal government buildings, or homes that serve as workplaces. The ordinance is enforced with a fine of up to $500 for any employer who fails to comply, however few problems with enforcement have been reported (Schuh, 1984).

Palo Alto's ordinance, passed in 1983 after San Francisco's ordinance, goes a step further by allowing a worker to declare his or her work area nonsmoking. According to the ordinance, "any employee in the office workplace shall be given the right to designate his or her immediate area as a nonsmoking area and to post it with appropriate signs or sign." The ordinance goes on to state that "in any dispute arising under the smoking policy, the rights of the nonsmoker shall be given precedence" (Palo Alto Ordinance 3476, in American Lung Association, 1985a). As with San Francisco ordinance, Palo Alto's ordinance does not apply to enclosed offices occupied solely by

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smokers, to State or Federal office buildings, or to private homes which serve as a workplace. Violation of the ordinance is an infraction of city code; fines range from $50 to $250.

As of March 1, 1986, 67 cities and towns and 7 counties in California have ordinances regulating smoking in the workplace (Americans for Nonsmokers' Rights, 1986). Across the State, 44 percent of the population falls under the jurisdiction of a local workplace smoking ordinance. For some companies with statewide offices, complying with the variety of ordinances in different cities has been something of a problem; the Pacific Telesis company in California developed a flexible corporate smoking policy in response to the situation (U.S. DHHS, 1985a).

County Ordinances

In 1984, Suffolk County in New York State adopted a workplace smoking ordinance for offices of 50 or more employees, similar in many ways to Palo Alto's city ordinance. According to the Suffolk ordinance, "any employee in the office workplace shall be given the right to designate his or her immediate area as a nonsmoking area and to post it with an appropriate sign or signs" (Amercian Lung Association, 1985a). However, unlike Palo Alto's ordinance, it adds that "in any dispute arising under the smoking policy, the rights of the nonsmoker shall be governed by the rule of reason and the economic practicability of action by the employer." The ordinance also prohibits smoking in many areas where both smokers and nonsmokers might be present, including conference rooms, auditoriums, restrooms, and elevators. The maximum fine for violation of the ordinance is $25.

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Nassau County, a neighbor to Suffolk County in New York, passed a smoking ordinance in January 1986 which limits smoking in the workplace to designated areas. Cited as "among the toughest in the country" (May, 1986), the ordinance bans smoking in many public places including hospitals, movie theaters, and stores and prohibits smoking in specific areas of the workplace, such as cafeterias, conference rooms, restrooms, and work areas. The ordinance states, however, that "an employer may designate a separate portion or portions of the work area, employees' lounge, and cafeteria, for smoking." Designating open work areas as smoking areas is discouraged by the County Board of Health if it conflicts with the intent of the ordinance, "to provide [county] residents protection from exposure to tobacco smoke" (Niebling, 1986). The ordinance is enforced by fines up to $500; two full-time administrators are currently assigned to administering the ordinance as it is phased in.

WORKPLACE SMOKING POLICIES IN THE PRIVATE SECTOR

Private sector smoking policies have shifted emphasis and increased in number in the last four to five years. In that time, nonsmokers' rights groups pressed for increased restriction of smoking in the workplace. Workplace smoking policies today are more likely to be based on consideration of the health and comfort of nonsmokers than policies four or five years ago, which tended to emphasize the protection of products and equipment and the prevention of fires and explosions.

Employer decisions to implement smoking policies are undoubtedly motivated by a number of factors, including concern for employee health and the costs of ill health, compliance with State and local laws, and a desire to reduce potential sources of conflict between employees. Employers may also wish to reduce their potential liability from lawsuits, and worker's

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compensation, unemployment benefits and disability benefit claims by passively exposed nonsmokers (see American Lung Association, 1985b; Cliff, 1984; Jauvtis, 1983; Ashe and Vaughan, 1985). However, the extent of this potential liability is currently unclear and is probably only a subsidiary motivation.

Smoking Policy Surveys

Survey data indicate that in 1980 most existing workplace policies were written with the intent to protect products and equipment in the workplace (Bennett, 1980), to accommodate customers and clients (Thomas, 1980), or to restrict smoking in blue collar work areas for reasons of workers' safety (National Interagency Council on Smoking and Health, 1980). Examples of these types of policies include smoking restrictions in food processing industries and bank lobbies and restrictions imposed to prevent fires and explosions.

Recent surveys of workplace smoking policies have been conducted by the Office of Disease Prevention and Health Promotion (ODPHP) (U.S. DHHS, 1986) in the Department of Health and Human Services and by a California consulting firm funded by the Tobacco Institute (Human Resources Policy Corporation, 1985). The ODPHP survey data are preliminary and will be released in final form in July 1986. The survey polled over 1,600 worksites with 50 or more employees nationwide on health promotion activities in the workplace, with a response rate of approximately 85 percent. The survey differs from previous surveys in that the sample consists of actual worksites defined by location, as opposed to central company offices. The survey conducted for the Tobacco Institute polled 1,100 large companies and had a rather low response rate of 40 percent. The companies chosen for the Tobacco Institute survey were drawn from the Fortune 1000 service and industrial companies and Inc. magazine's 100 fastest growing companies.

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Both surveys, though based on very different samples of workplaces, produced similar estimates of the prevalence of workplace smoking policies. The ODPHP survey found that 36 percent of worksites with 750 or more employees had smoking policies, while the Tobacco Institute survey found that 32 percent of large corporations surveyed had a smoking policy.

One conclusion drawn in the Tobacco Institute study, that "workplace smoking policies are not a trend among major companies," does not appear to be supported by their data. The survey indicates that 9 percent of the companies with smoking policies had developed them in the year before the survey, and 20 percent in the previous five years. These data should be interpreted cautiously, however, as nearly 60 percent of those responding did not know how long the policy had been in effect.

Preliminary results from ODPHP survey indicate that nonsmokers' concerns and regulations requiring smoking policies have become primary reasons for workplace smoking policies (U.S. DHHS, 1986). Results suggest that 27 percent of all worksites with 50 or more employees have some form of smoking policy, and that the primary purpose of 40 percent of these policies was to "protect nonsmokers." Another 40 percent were written to "comply with regulations," and thirteen percent of the policies were written to "protect equipment." The primary purpose for seven percent of the policies was "to protect high risk employees," such as asbestos workers.

Private Sector Smoking Restrictions

Private sector businesses demonstrate a variety of approaches for accommodating nonsmokers' concerns. Although this report focuses on policies, it should be mentioned that many private sector businesses also use smoking cessation programs and incentives to help employees quit smoking in

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conjunction with the policies. The most widely used cessation programs according to preliminary results from the ODPHP survey are self-help program materials to be used on the smoker's own time. These include information packets and videotapes from sources such as the American Lung Association. Some businesses offer financial incentives such as bonuses for smoking abstinence (see the 1985 Surgeon General's report (U.S. DHHS, 1985b) for a review of cessation programs and incentives).

It is not always possible to neatly categorize the motives and expectations behind specific private sector policies. Private sector workplace smoking policies range from policies concerned primarily with occupational safety and product purity to a growing number of policies concerned with nonsmokers' health and comfort. Some industries, such as health and insurance industries, are especially inclined to restrict smoking for health reasons. The airline industry is required by Federal regulations establish smoking and nonsmoking sections in all large aircraft and to prohibit smoking on aircraft with less than 30 seats (14 CFR part 252).

OTA focuses in this section on the workplaces that have developed a workplace smoking policy. Data indicate that the majority of businesses do not have a policy; however, the increasing number of State and local laws regulating smoking as well as the greater awareness of nonsmokers' concerns reflected in the ODPHP survey (U.S. DHHS, 1986) suggest that the number of workplace smoking policies is increasing. OTA is unaware of businesses that have chosen to rescind a policy after accepting one.

Restricting smoking in certain areas. Smoking is often banned in specific areas outside the actual work area. These policies ban smoking in areas such as meeting and conference rooms, auditoriums, elevators, bathrooms, and hallways. Although survey information is not available on the prevalence

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of this type of policy, it appears to be the most common type (U.S. DHHS, 1985). Often State laws or local ordinances prohibit smoking in areas such as elevators; in 1984, 40 States and the District of Columbia prohibited smoking in certain public areas (U.S. DHHS, undated). Some companies have used this type of policy as a first step in creating a more comprehensive workplace smoking policy. The Boeing Company in Seattle currently designates nonsmoking areas, but has announced its intent to ban smoking entirely (U.S. DHHS, 1985a; Sifferman, 1986).

Surveys in 1980 indicate that 54 percent of large Massachusetts businesses had work areas where smoking was prohibited because of potential damage to products or equipment (Bennett, 1980), and smoking is often restricted in blue collar work areas because of safety reasons (National Interagency Council on Smoking and Health, 1980). Businesses where contact with clients is frequent often restrict smoking in lobbies and other client contact areas. A 1980 survey of 500 members of the Administrative Management Society found that 46 percent of those who responded prohibited smoking in areas where employees came into contact with customers and clients, making it the most common policy among that service- and client-oriented group of businesses (Thomas, 1980). The policies did not restrict smoking in common work areas, rather they prohibited it in areas where clients would be present, such as at bank teller windows. Therefore, these policies apply only to employees who normally work with clients.

Modifying the work environment. Although not so much an explicit policy or restriction as a more general means of accommodating smokers and nonsmokers, modifying the work environment is a step taken by many employers. Modifications range from posting signs to separating work areas and improving ventilation. Sometimes workplace modification is a step taken before more

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explicit policies are developed. In 1979, the Control Data Corporation in Minneapolis separated work areas into smoking and nonsmoking sections and designed ventilation systems to blow smoke away from nonsmokers; in 1984, Control Data banned cigarette smoking except in designated areas (Business Week, 1982; U.S. DHHS, 1985a). One factor limiting the extent of workplace modification is cost; Minnesota's state law, for instance, requires only that "existing physical barriers and ventilation systems" be used in separating smoking and nonsmoking areas, rather than requiring new structures.

Banning smoking except in designated areas. Some businesses have prohibited smoking in the workplace except in designated areas. Five States currently have laws requiring private sector employers to restrict smoking to designated areas (see Table 2). The Control Data Corporation in Minnesota, which has such a law, prohibits smoking in all areas except in private offices, sections of cafeterias and conference rooms, and certain refreshment rooms (Andrew, 1986). MSI Insurance, also in Minnesota, limits smoking to part of the cafeteria (U.S. DHHS, 1985a). Some State health officials OTA contacted had received complaints from nonsmokers in businesses where smoke from designated areas drifted into the work area (Richards, 1986; Maloney, 1986).

Banning smoking throughout the workplace. Recently a small number of companies have banned smoking entirely from the workplace. Pacific Northwest Bell based in Seattle banned smoking in October 1985, a policy recommended by an employee committee after two years of review. The company had also conducted a survey of employees which indicated that most employees wanted a policy regulating smoking in work areas (Mozmette, 1986). The Provident Indemnity Life Insurance Company in Norristown, Pennsylvania banned smoking on company property in the fall of 1983. The company reached that stage in

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steps, first by limiting smoking to the lunchroom during a certain time period, and then by altering its job application so that applicants would be aware that smokers must abide by the policy and pay for insurance at a greater rate than nonsmokers (U.S. DHHS, 1985). The CIGNA Health Plan of Arizona, a Health Maintenance Organization centered in Phoenix, banned smoking in April, 1985, after a resolution to make hospitals smoke free passed at a meeting of the Arizona Medical Association (Larson, 1986).

These bans seem to have been implemented smoothly, but an employer may have problems declaring a total ban if the employer declares the ban unilaterally when labor negotiations are required. In an arbitration case in California, an employer's ban was declared unreasonable by an arbitrator because it did not cite sufficient reasons for the ban and the ban had been declared unilaterally by management (Jauvtis, 1983).

Although their numbers appear to be small, some employers also have a policy against hiring smokers. The Johns-Manville asbestos company stopped hiring smokers in 1978 (U.S. DHHS, 1985b), and some fire departments have recently decided to hire only nonsmokers (NJ GASP, 1985).

SUMMARY: WORKPLACE SMOKING POLICIES

Approximately 30 percent of all private sector workplaces have a formal smoking policy, while a majority of Americans support smoking policies. Governments at all levels and the private sector are increasingly adopting or strengthening such policies and there is no evidence of retrenchment. In addition, the protection of nonsmokers, who account for 67 percent of the population, has become a primary motive for the development of policies. For these reasons, OTA believes that increasing adoption of increasingly stringent workplace smoking policies will likely continue for the foreseeable future.

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COST-EFFECTIVENESS OF SMOKING POLICIES

Previous studies of the costs of smoking have focused on costs related to active smoking. Taking a society-wide perspective, OTA estimated that 314,000 deaths in 1982 were attributable to smoking--139,000 cancer deaths, 123,000 cardiovascular disease deaths, and 52,000 chronic obstructive lung disease deaths. The social costs attributable to those deaths include $12 to $35 billion in health care costs and $27 to $61 billion in lost earnings (OTA, 1985). There have also been analyses of the costs of active smoking from the perspective of the individual (Oster, et al, 1984) and the employer (Kristein, 1983; Weiss, 1981).

The costs and benefits of policies concerning smoking in the workplace, however, have not been extensively analyzed. An analysis depends, of course, on both the costs of implementing the policies and on their benefits. Any analysis should also clearly identify its perspective--e.g. whether the effects arrayed are costs or benefits to society, to employers, to smokers, or to nonsmokers. In addition, while workplace smoking policies will certainly affect nonsmokers' exposures to passive smoking, these policies may also influence the extent of active smoking by smokers.

Proposed legislation (S. 1937, 99th Congress) would require Federal agencies to issue rules to designate smoking areas in U.S. Government buildings. These rules, to be developed in consultation with the Surgeon General and implemented after consultation with employee representatives, are to "make reasonable accommodations for the needs of the smokers and nonsmokers" who use Federal buildings, provide for display of signs designating smoking and no smoking areas, and provide for enforcement of smoking prohibitions in no smoking areas. Each of the components of this

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proposed legislation will affect the degree of nonsmokers' exposures to tobacco smoke and influence the nature of the relationships between smokers and nonsmokers in the workplace.

While policies concerning smoking in the workplace seem to be successful, information on the costs and effects of these policies is difficult to obtain. Because of this quantitative limitation, OTA has not attempted to conduct a cost-benefit or cost-effectiveness analysis of workplace smoking policies. Instead, this section discusses some of the factors that would need to be considered when evaluating the costs and effects of these policies.

Benefits of Workplace Smoking Policies

As mentioned earlier, one recent survey indicates that a large majority of the U.S. population believes smokers should refrain from smoking in the presence of nonsmokers and that companies should limit smoking to designated areas. While this expressed preference would be difficult to incorporate into an economic analysis of smoking policies, it is still an important consideration in any decision concerning the creation of such policies. Another important consideration, difficult to incorporate in an economic analysis, is how the setting of workplace policies by the Federal Government will accelerate the current trends toward increased adoption of smoking policies by other levels of government and by private employers.

If workplace policies lead to reductions in exposure to passive smoking, then there should be a reduction in the incidence of smoking-related disease among nonsmokers. If treatment of these diseases requires the use of medical resources, less disease would imply savings in health care costs. Generally, reducing the incidence of nonfatal disease will lead to saving

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health care resources. Depending on the extent that these health care costs are paid for by insurance, saving health care resources should lead to a reduction in the costs of health insurance.

If the diseases caused by passive smoking are fatal, prevention will result in longer life. During the additional years of life gained, additional medical resources will be used. Thus, preventing an early death may lead to savings in health care costs in the present and increases in health care costs in future years. The net effect depends on the relative costs of the diseases in question and the discount rate used in the analysis of future effects. However, analysts disagree on whether these potential future costs should be included in a cost-effectiveness analysis (see OTA, 1985).

Life insurance rates will only be affected if the passive smoking-related diseases are fatal. Reducing the death rate of an insured group should lead to a reduction in the costs of providing life insurance. This extent of this reduction will depend on the size of the increase in longevity.

A few companies have restricted employment to nonsmokers in a desire to reduce the incidence of occupational disease and associated workers' compensation payments. For example, the combined effect of exposures to asbestos and cigarette smoking is much greater than the effect of exposure to only asbestos or cigarette smoke. Hiring only nonsmokers might reduce the costs of compensating workers with asbestos-related disease, although reductions in asbestos exposures represent another alternative.

Eliminating smoking from the worksite would eliminate the workplace fires started by burning cigarettes. The effect of confining smoking to designated areas is less clear. Fire prevention and control might be better if smoking is restricted to particular locations, although actions might be needed to prevent smoking in non-designated areas. The reduction in the

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frequency of fires and associated property damage should lead to reduction in the costs of fire losses and insurance. Of course, the magnitude of this benefit will depend on the proportion of fires associated with smoking.

Reducing workplace smoking may also lead to reductions in the costs of cleaning and maintaining the workplace. This may include reductions in the costs of cleaning offices, a lessened need to clean and repair sensitive equipment, as well as a reduction in the costs of maintaining the ventilation system, e.g., in cleaning or replacing filters. Reduced workplace smoking may also improve relations with customers who are irritated by tobacco smoke.

The beneficiaries of any of the reductions in insurance costs depends on the method used for financing the insurance (in particular, the relative shares of the employer and the employee). Thus the analysis needs to be clear about who receives any particular benefit and who bears the costs of these policies.[2]

Several sources indicate that smokers have more sick loss days than nonsmokers, although this excess may not be entirely due to smoking (see OTA, 1985). If passive exposures also lead to an increase in sick time, then reducing passive exposures should lead to reductions in employee absenteeism among nonsmokers.

Workplace smoking policies should also reduce or eliminate the irritation and annoyance experienced by nonsmokers when exposed to tobacco smoke. In many cases, tobacco smoke is part of the more general problem of indoor air pollution. Investigation of complaints about indoor air quality only rarely finds tobacco smoke to be the sole source of the problem (Robertson, 1986). But while indoor air pollution and the "sick building

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[2]It should also be noted that, in most cases, insurance payments represent transfers and, strictly speaking, may not be social costs.

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syndrome" are often the result of inadequate ventilation and exposures to other toxic agents, exposure to tobacco smoke is frequently a factor in complaints of ill health associated with office work (Melius, 1986).

Thus improving the comfort of nonsmokers and reducing tobacco smoke-induced irritation is an important benefit of these policies. Economists often suggest that the most appropriate way to place a monetary value on nonsmokers' comfort would be to estimate how much nonsmokers might be willing to pay to avoid environmental tobacco smoke. Thus, on the benefit side would be how much nonsmokers would be willing to pay to reduce or eliminate exposure to tobacco smoke. On the cost side would be estimates of how much smokers might be willing to pay to continue to smoke without restrictions. But, reliable estimates of willingness to pay are difficult to obtain and would be influenced by the income levels of the individuals affected. In addition, ethical arguments are likely to be raised. Many consider clean air to be a right and, thus, reject the idea that nonsmokers should have to pay in order to breathe clean air. Others express concern that employers and the government have no right to restrict an individual's decision to smoke.

The intended effect of smoking policies is to reduce or eliminate the exposures of nonsmokers to tobacco smoke. Another possible effect is that, faced with restrictions concerning when and where they may smoke, some smokers may reduce the amount of their smoking or give up the habit entirely. Surveys regularly report that a large majority of smokers would like to quit and that many have tried to quit. A survey at one company (Pacific Bell, now called Pacific Telesis) indicated that if a new company policy concerning smoking in the workplace was implemented, 13 percent of the smokers would try to quit and 38 percent would smoke less (Eriksen, 1985). Thus, even though the primary purpose of these policies is to reduce or eliminate nonsmokers passive

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exposures, the implementation of workplace smoking restrictions may also motivate, encourage, or support the decisions of smokers to reduce their consumption or stop smoking entirely. Of course, if smokers quit in response to workplace smoking restrictions, their families will no longer be passively exposed, leading to additional health benefits among family members.

Costs of Workplace Smoking Policies

Each component of workplace smoking policies will also create implementation costs. For example, if a smoking policy includes the use of signs to indicate smoking and nonsmoking areas, the costs of the signs will need to be included in any evaluation. While it might be desirable to analyze separately the costs and effects of each component, it is likely to be difficult.

Even when considering a policy as a whole, it will be difficult to estimate the additional administrative costs that a smoking policy might create for employers. Once they are established and implemented, it is likely that smoking policies will simply be administered along with the other employer policies concerning personnel and buildings. It will thus be difficult to separate the costs of administering the smoking policy from the general costs of administration.

Restrictions on smoking may lead to changes in employee productivity. Some analysts have suggested that smokers are less productive than nonsmokers because of the time lost while smoking. Depending on where smoking is permitted and the design of the workplace, the extent of this possible time loss may change. If smokers need to travel far from their desks to smoke, the total time lost may increase. If they can continue to smoke at their desks, the time lost through smoking will stay the same. If smokers reduce their on-

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the-job smoking, the amount of time lost may go down. Without the irritation of tobacco smoke, the morale of nonsmokers may improve and they may become more productive. If time has been lost because of conflicts between smokers and nonsmokers concerning where smoking is permitted, implementation of a smoking policy could reduce those conflicts and the consequent productivity loss.

Consideration of Alternatives

An important part of a cost-effectiveness analysis is the consideration of alternatives. Of course, one possible alternative is to do nothing. From a social perspective, no laws or regulations would be enacted. This would leave smokers and nonsmokers, employers and workers, to work out their own arrangements. Under certain very restrictive assumptions concerning the nature of markets and the decisions of employers, workers, and consumers, it is has been suggested that a freely operating market system will generate the best possible combination of smoking and nonsmoking policies, prices, and wages (Tollison, 1986). If this is believed to be the case, then there would be no need for additional government action concerning private sector smoking policies.[3] However, the conditions necessary for this conclusion are very restrictive and unlikely to exist.

Beyond the possibility of no action, several alternatives are available to handle the problem of passive smoking, one possibility is to establish smoking policies to designate smoking and nonsmoking areas in the workplace and to make accommodations for the needs of smokers and nonsmokers. Another alternative is physical modification of the workplace to separate smokers'

[3]There still, however, may be a need for government action (legislation, regulation, labor-management negotiation) to set policies for its own workplaces.

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work areas from those of nonsmokers.

Finally, the ventilation system could be redesigned to increase substantially the air flow in all areas to reduce the nonsmokers' exposures to tobacco smoke. For example, the current guidelines of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) set a ventilation rate of 5 cubic feet per minute of fresh, outside air per person for general office where smoking is not permitted. For office areas where smoking is permitted, the standard is 20 cubic feet per minute per person. The cost of providing additional ventilation depends on the layout of the building and the amount of heating or cooling that this additional outside air requires. Additional ventilation will also provide an extra benefit by reducing the concentrations of other indoor pollutants that workers may be exposed to.

For each of these, a complete listing of the costs and effects would be desirable. However, even without conducting a comprehensive analysis, it appears likely that physical modification of the workplace or the use of additional ventilation would be substantially more expensive than establishing policies concerning smoking in the workplace.

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